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Developmental screening in context: adaptation and standardization of the Denver Developmental Screening Test-II (DDST-II) for Sri Lankan children

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Keywords
Culture and context in early developmental screening, Denver Developmental Screening Test II (DDST-II), development of Sri Lankan children, ecological model, test standardization and adaptation

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Abstract
Background Developmental problems in children can be alleviated to a great extent with early detection and intervention through periodic screening for developmental delays during pre-school ages. Currently, there is no established system for developmental screening of children in Sri Lanka. Although some developmental norms, which are similar to those of Denver Developmental Screening Test-II (DDST-II), have been introduced into the Sri Lankan Child Health Developmental Record (CHDR), those norms have not been standardized to the Sri Lankan child population. The aim of this research was to establish Sri Lankan norms for DDST-II and to test the universal and regional applicability of developmental screening tests by comparing the Sri Lankan norms with the norms of DDST-II and DDST-Singapore norms, the geographically nearest standardization of DDST-II. The norms were also compared with the milestones already available in the CHDR.
Methods DDST-II was adapted and standardized on a sample of 4251 Sri Lankan children aged 0–80 months. Thirteen public health nursing sisters were trained to collect the data as part of their routine work. The 25th, 50th, 75th and 90th percentile ages of acquiring each developmental milestone were then calculated using logistic regression.
Results The Denver Developmental Screening Test for Sri Lankan Children (DDST-SL) was created. Most of the established DDST-SL norms were different to the comparable norms in DDST-II, DDST-Singapore and the CHDR.
Conclusions In view of the results of the study, it is imperative that developmental screening tests are used in context and are adapted and standardized to the populations in question before utilization.

Introduction

Early developmental screening

Over the years, there has been an increasing recognition of the importance of early developmental screening and intervention in the pre-school years. Child development is a dynamic process, which involves development in various areas such as motor, language and psychosocial domains. Given that the pattern and rate of development may also differ from child to child, it is often difficult to detect mild developmental delays and deviations at a glance (Committee on Children with Disabilities 2001). Children who do not manifest obvious socioemotional, behavioural or neurological dysfunctions in early childhood may remain undetected of their developmental disabilities until onset of schooling (Williams & Holmes 2004). Early detection and intervention through periodic screening during pre-school ages can alleviate developmental problems to a great extent and help children achieve their full potential in physical, behavioural and socio-emotional capacities (Glascoe 2005; Rydz *et al*. 2005; Bayoglu *et al*. 2007).

Child health monitoring system in Sri Lanka

Children under the age of 5 constitute 11.8% of Sri Lanka's population of approximately 20.7 million (Department of Census and Statistics 2010). The curative and primary healthcare systems in Sri Lanka are well established and health care is provided free of cost to all by the government. Owing to this system, Sri Lanka maintains low infant mortality and maternal mortality ratios compared with other countries in South Asia (UNICEF 2008).

In Sri Lanka, every child receives a Child Health Developmental Record (CHDR) at birth and all children are routinely immunized and monitored for physical well-being. However, there is no established developmental screening system to monitor the psychosocial development of children in Sri Lanka. Although some developmental milestones have been introduced into the recent CHDR, which are very similar to those of the Denver Developmental Screening Test-II (DDST-II), they have not been standardized to the Sri Lankan population. Furthermore, the milestones do not form part of a screening programme aimed at early intervention and are included in the CHDR only as guidelines for parents and health workers.

Denver Developmental Screening Test

The DDST-II was the preferred data collection tool for this study due to its similarity with the milestones in the CHDR and its focus on the development in the pre-school years. DDST was first published in 1967 and norms for DDST-II were established in 1988–1989 on a sample of children from Denver, CO, USA. DDST-II, which consists of 125 items, is similar to a growth chart where a child's developmental trajectory can be monitored and mapped on a chart from 2 weeks of age until 6 years of age (Frankenburg *et al*. 1992a,b). A child is assessed in the presence of the caregiver and the development is measured mainly through the child's performance on the 125 items. The test usually takes 10–20 min on average to administer and can be administered by trained professionals and paraprofessionals. The administration procedure is simple and the test is designed as a screening procedure to indicate if a child '*passes*', '*fails*', '*refuses*' or '*has not had the opportunity*' to develop the proficiency to attain age-appropriate developmental milestones.

The items in DDST-II address four separate domains of development: (i) *personal-social* items assess the level of interaction with people and ability to care for own needs; (ii) *fine motor-adaptive* items assess eye–hand co-ordination, manipulation of small objects and problem-solving capacities; (iii) *language* items assess children's development in terms of hearing, understanding and usage of language; and (iv) *gross motor* items assess a child's overall movement such as the ability to sit, walk and jump. Consideration of different domains of development is of great importance as it is possible for a child, who may be developing well in one domain, to be delayed in the development of another (Frankenburg *et al*. 1992a,b). It can also enable healthcare providers to isolate specific problem areas, enabling interventions to be individually tailored to children. Although DDST-II is reported to have excellent sensitivity (low false negative rate) (83%), its low specificity (high false positive rate), has been questioned (Glascoe *et al*. 1992; Glascoe 2002). On the other hand, other research has indicated that the high false positive rate can be reduced by means of clinical judgement and repeat screening and that it is a useful tool to identify children who are developmentally delayed, who would otherwise be missed (Lim *et al*. 1996).

Considering child development in context

It has been argued that development could be viewed as either *universal*, *culturally relative* or *absolute* (Berry 2000). However, the trend to search for absolute and universal trends in child development has shifted over the years to take into consideration the dynamic and interactive influences of ecological variables surrounding children. This school of thought has been most influenced by the work of Bronfenbrenner and his (bio)ecological theory (Bronfenbrenner 1979a,b, 1999, Bronfenbrenner & Evans 2000). The theory postulates that human development is a product of the processes and dynamic interactions between the individuals and their contexts. The contexts of development include *microsystem* (the immediate environments of a child, such as family and day care setting), *mesosystem* (the interactions between different *microsystems* of a child), *exosystem* (the non-immediate environments such as parents' work place and the community which may indirectly influence a child's development) and *macrosystem* (societal beliefs, culture, law, customs, etc.), which all change with *time* (transitions over the life course, environmental events and sociohistorical circumstances).

Other proponents of the ecological model have theorized that environmental characteristics such as natural resources, climate and physical environment should also be considered alongside psychosocial environments for a better understanding of the variability in children's behaviour and development (Wachs 2003; Evans 2006).

The ecologies of children differ from country to country. Most developmental screening tests, including DDST-II, have been standardized on samples from Western child populations. Consequently, the use of those test norms may lead to erroneous test results as they may not be comparable across child populations in all countries. For example, a false positive diagnosis of a developmental concern could lead to inefficient use of public resources and above all, an unnecessary emotional ordeal for a child and the family in consideration (Vameghi *et al*. 2010). For this reason, to yield valid results, a developmental screening test should be standardized on the intended population (Committee on Children with Disabilities 2001; Frankenburg 2002).

The aim of this research was to establish Sri Lankan norms for DDST-II and to test the universal and regional applicability of developmental screening tests by comparing the Sri Lankan norms with the norms of DDST-II and DDST-Singapore, the geographically nearest standardization of DDST-II. The norms were also compared with the milestones already available in the CHDR.

Methodology

Sampling frame

The aim of the research was to establish developmental norms for Sri Lankan children aged 2 weeks to 6 years. All children attending child health clinics in 11 out of 25 districts in Sri Lanka were considered as the sampling frame. The sampling frame included 46% of infants (*n* = 154 896) and 46% of pre-schoolers (*n* = 602 679) registered at child health clinics in Sri Lanka. Ninety-seven per cent of infants and 80% of pre-school children in Sri Lanka visit the child health clinics at least once and 83% infants and 47–57% pre-schoolers visit the clinic every month to be weighed (Family Health Bureau 2009). The 11 districts were chosen to represent a cross section of ethnic and socio-economic strata in the country. As 80% of the Sri Lankan population live in rural areas (Department of Census and Statistics 2004), the number of districts with more urban and estate areas were increased for a better representation of these groups.

Sample design

The study adopted a quota sampling procedure for adequate representation of the age ranges of children and subgroups (sex and place of residence) in the population. Although the purpose of the study was to establish norms for development of children up to 72 months of age, the target age range was extended up to 80 months to allow for statistical analysis. In keeping with the original DDST-II standardization procedure, the sample was split into 10 age groups to maximize the data points across each age range. The total sample size required was 3840 (95% confidence interval; margin of error _5%). The actual sample selected for the study consisted of 4680 children, meeting quota proportions in terms of place of residence (urban, rural and estate), sex (male, female) and age (10 age groups). The purpose of the standardization was to establish developmental norms for healthy and 'normal' Sri Lankan children. Therefore, as has been done in other standardizations (Frankenburg *et al*. 1992a; Lim *et al*. 1994), only children who were born at full term, who had not been clinically diagnosed with any developmental disability, not suffering from any chronic or acute health indication at the time of testing were included in the sample. The screened-out rate was 8% (*n* = 360). The sample was restricted to one child per family.

The test

The DDST-II test form, training manual and technical manual were translated into Sinhalese and Tamil, the main languages of Sri Lanka. The translation was carried out by official translators and the translated material was subsequently scrutinized by a panel consisting of a paediatrician, two consultant community physicians and the principal investigator. Five of the 125 translated items were subsequently revised, to be more culturally appropriate (see Table 1).

Training

Thirteen public health nursing sisters (PHNS) and their supervising medical officers from11 districts were trained over 2 days on the utilization and administration of DDST-II in compliance with the guidelines of the training manual. Two districts had two PHNS each due to the large size and the variation of the population in those districts.

Data collection

The data were collected between June 2006 and November 2006. Each PHNS was required to test 360 children. The data collection was carried out as part of routine work of the PHNS under the supervision of the medical officers and the testing was carried out in homes, weighing centres, clinics and crèches in the presence of parents/guardians. Prior to conducting the test, the PHNS were required to provide an outline of the study to the parents/guardians and seek consent for the child's participation in the study. The PHNS did not report any refusals. Each child was tested in the language most familiar to him or her and was rated as *Pass / Fail / No opportunity / Refusal* outcome for each of the items in the translated DDST-II. In cases where the children were uncooperative, distressed or fatigued during testing, the testing was postponed and the children were tested again on another day.

Table 1. Modified and adapted items

Original DDST-II Item	Adapted Item	Rationale for change
Use spoon/fork	Use fingers to eat	Most Sri Lankans use their fingers to eat with and do not use other utensils.
Play pat-a-cake	Clapping	Sri Lankan children do not play this game
Play card/board games	Play interactive games (wait for turn)	Sri Lankan children do not have a culture of playing many card/board games
Prepare cereal	Serve food alone	Sri Lankan children do not have a culture of eating cereal for breakfast
Picture of horse for *name pictures* item	Picture changed to a cow	Cows are more common than horses in Sri Lanka

Reliability

To establish consistency of test administration within the data collection team, inter-examiner reliability was calculated between the principal investigator and each of the 13 PHNS during training and data collection phases at least twice (n = 48). All kappa values were high, ranging from 0.80 to 1 (M = 0.96, SD = 0.04).

Data analyses

All items in the questionnaire were administered to each child in the sample. The main objective of the analyses was to determine the 25th, 50th, 75th and 90th percentile passing ages of Sri Lankan children for all items in the questionnaire. A *percentile passing age* is the age before which a certain percentage of children in the population are able to attain a developmental milestone (e.g. the 90th percentile age for walking is the age by which 90% of the population are able to walk). Of the 125 items administered, logistic regression analyses were conducted on 122 items with age as the predictor and performance on an item (pass/fail) as the outcome variable. The purpose of logistic regressions was to carry out a criterion-referenced validation procedure, with age being the most pertinent developmental criterion. Three items were not analysed due to low reliability. *Feed self* was taken out as Sri Lankan mothers are advised to breastfeed exclusively until children are 6 months of age. In addition, *copy square demonstrated* and *balance each foot 5 s* items were excluded from the analyses. The resulting regression values were used to calculate the 25th, 50th, 75th and 90th percentile passing ages for each item. The 90th percentile passing ages for Sri Lankan children were then compared with the 90th percentile age norms of DDST-II and DDST-Singapore. The DDST-II norms were taken from the DDST-II technical manual while the DDST-Singapore norms were extracted from an article on the standardization of DDST-II for Singapore children (Lim *et al*. 1994).

Results

Response sheets of 4251 of the 4320 children screened were retained for analyses. The others were excluded due to incomplete information on data collection sheets (e.g. a child's age). The age range of the 4251 children on the day of testing was 3 days to 80.5 months. The proportional distribution of the children in the study sample by place of residence, sex and ethnicity, which is a direct result of quota sampling, is presented in Table 2.

Table 2. Profile characteristics of the sample (*n* = 4251)

	Number in Sample	% in Sample	% in Population*
Place of Residence			
Rural	1795	42.5	80.1
Urban	1452	34.4	14.6
Estate	973	23.1	5.3
Sex			
Female	2120	49.9	51.5
Male	2128	50.1	49.5
Ethnicity			
Sinhalese	2335	55	81.9
Tamil	1348	31.7	9.5
Muslim	556	13.1	8
Other	7	0.2	0.6

*Based on Sri Lankan National Census (2001).

Denver Developmental Screening Test for Sri Lankan Children (DDST-SL) test form

Logistic regression was statistically significant (at $P < 0.05$) for 119 items of the 122 items analysed (27 *fine motor-adaptive*, 23 *personal-social*, 31 *gross motor* and 38 *language* items). This indicated that age reliably distinguished between the children who passed and those who failed an item. With regard to the three items where logistic regression modelling was not possible, it was considered that the children should be able to *pass* these milestones at birth as all children passed all these three items (*regard face*, *follow to midline* and *equal movements*). The calculated percentiles for each item were used in graphing the DDST-SL in the same format as DDST-II. Each item/milestone is represented by a bar depicting the 25th, 50th 75th and the 90th percentile passing ages. An extract of the DDST-SL form is illustrated in Fig. 1.

Comparison of the norms of DDST-SL with DDST-II and DDST-Singapore norms

The 90th percentile ages of attaining milestones were considered for the comparison of test norms. One hundred and eighteen items of DDST-II and 84 of DDST-Singapore items were comparable with the DDST-SL items. Overall, when compared with both DDST-II and DDST-Singapore, DDST-SL showed more than a month's difference in the ages of attaining milestones in more than 75% of items in all domains (see Figs 2 & 3).

The three versions of the DDSTs were also compared against each other. The 82 items comparable across all three screening tests are graphically represented in Figs 4–7. As can be seen, although there were differences in the rate of development, the patterns of development were very similar across the three tests.

Figure 1. An extract from the Denver Developmental Screening Test for Sri Lankan Children (DDST-SL).

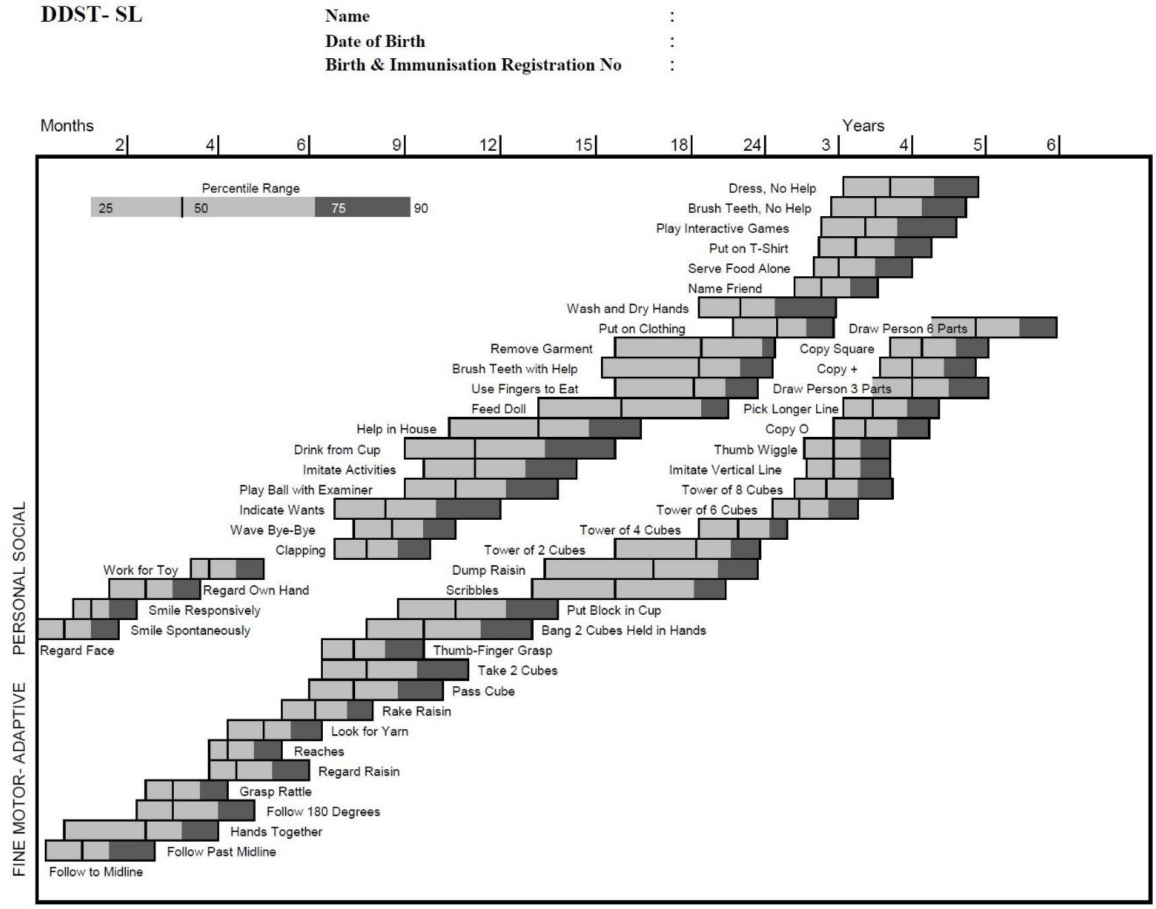


Figure 2. Comparison of the Denver Developmental Screening Test for Sri Lankan Children (DDST-SL) norms with the Denver Developmental Screening Test-II (DDST-II) norms (differences of more than a month at 90th percentile age considered).

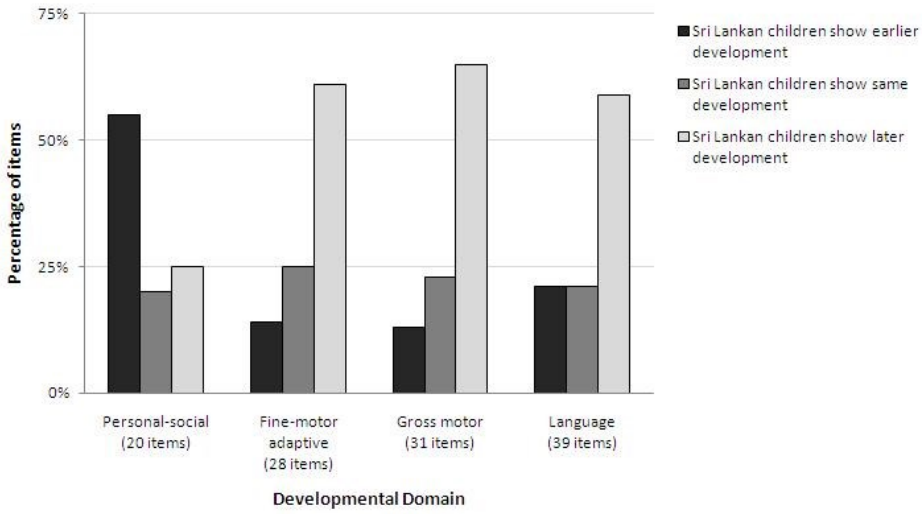


Figure 3. Comparison of the Denver Developmental Screening Test for Sri Lankan Children (DDST-SL) norms with DDST-Singapore norms (differences of more than a month at 90th percentile age considered).

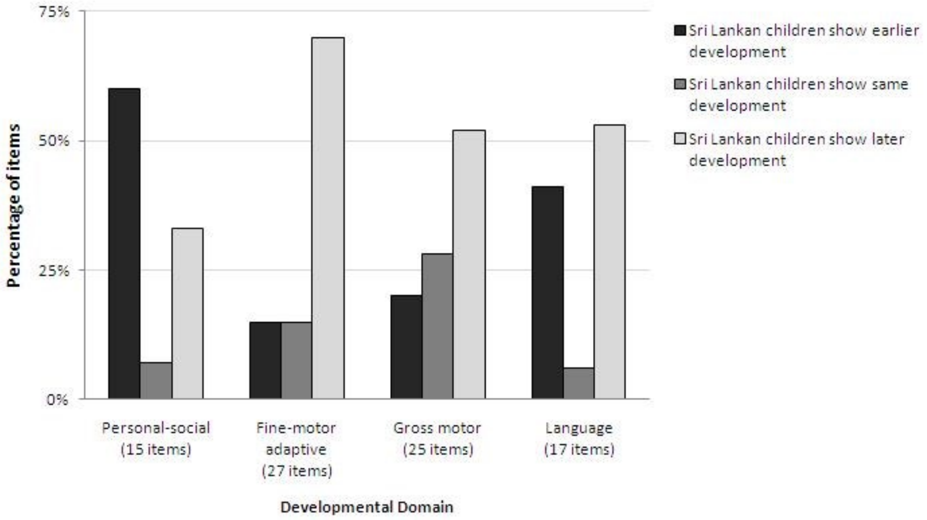


Figure 4. Comparison of the Denver Developmental Screening Test for Sri Lankan Children (DDST-SL), the Denver Developmental Screening Test-II (DDST-II) and DDST-Singapore personal-social milestones (90th percentile age considered).

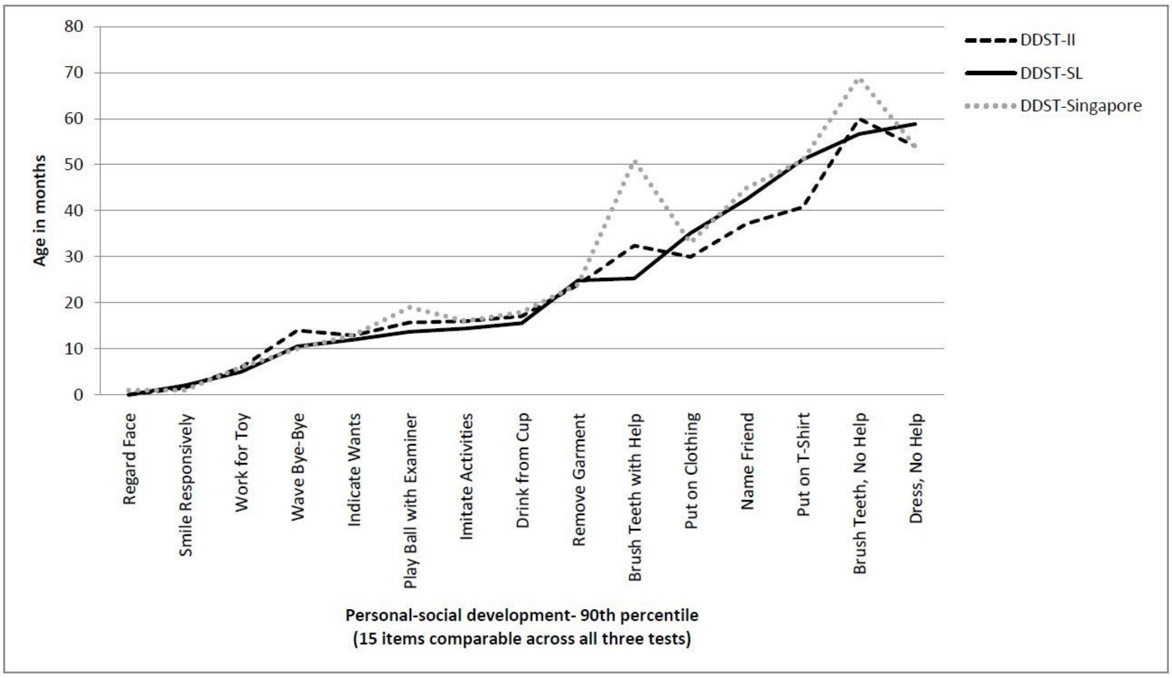


Figure 5. Comparison of the Denver Developmental Screening Test for Sri Lankan Children (DDST-SL), the Denver Developmental Screening Test-II (DDST-II) and DDST-Singapore fine motor-adaptive milestones (90th percentile age considered).

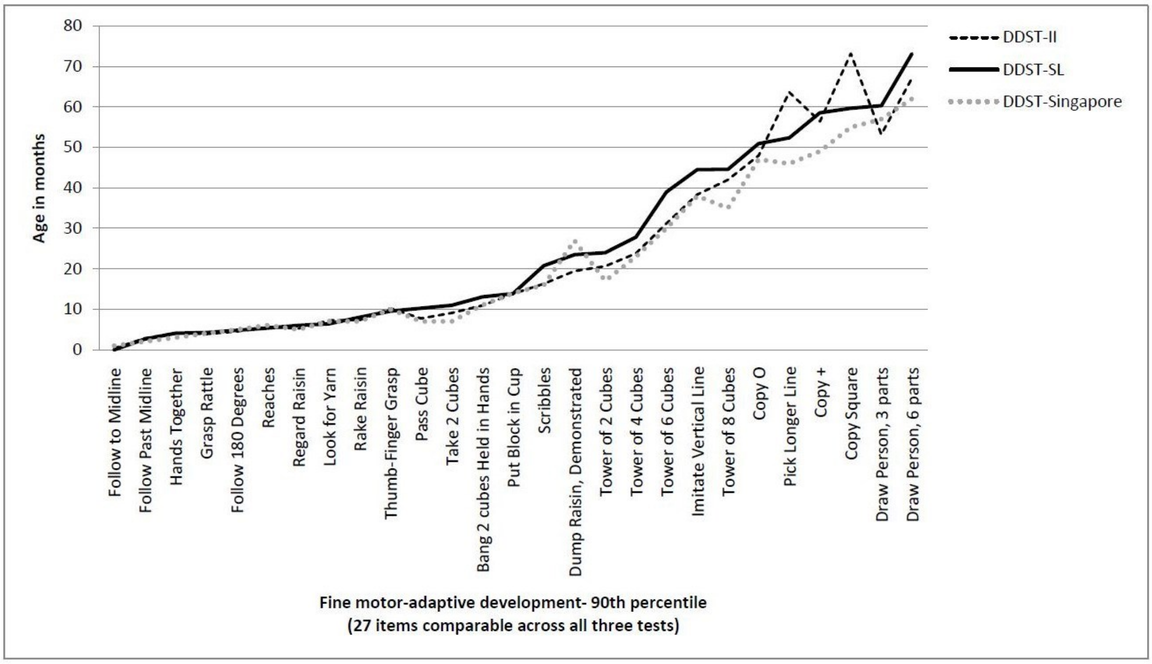


Figure 6. Comparison of the Denver Developmental Screening Test for Sri Lankan Children (DDST-SL), the Denver Developmental Screening Test-II (DDST-II) and DDST-Singapore gross motor milestones (90th percentile age considered).

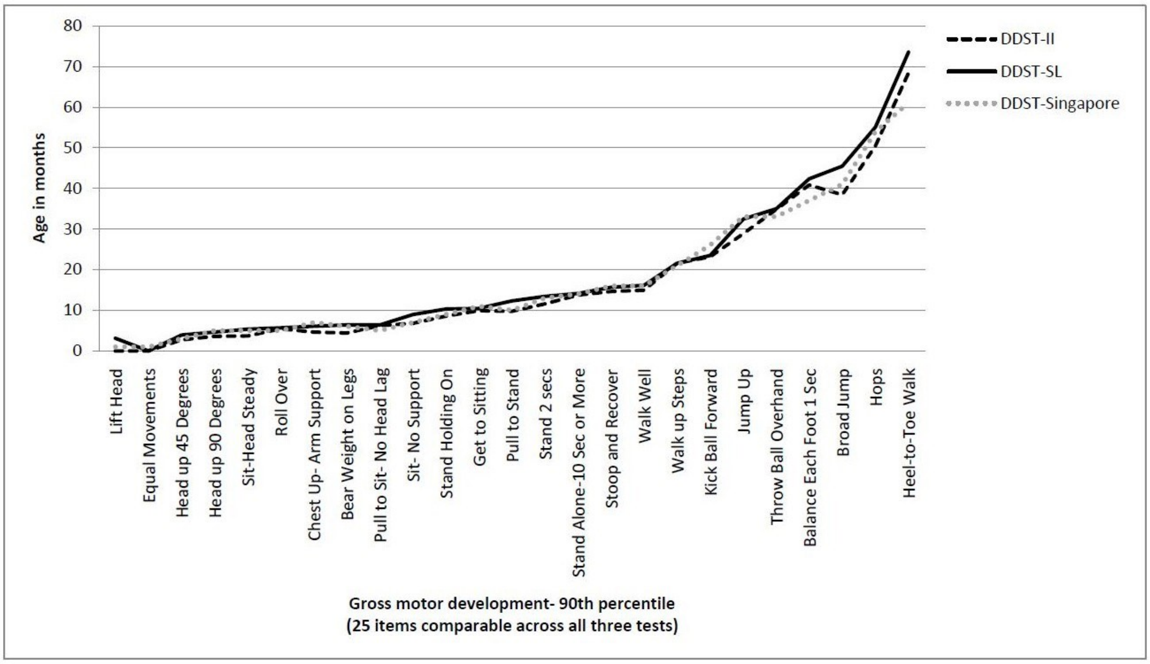
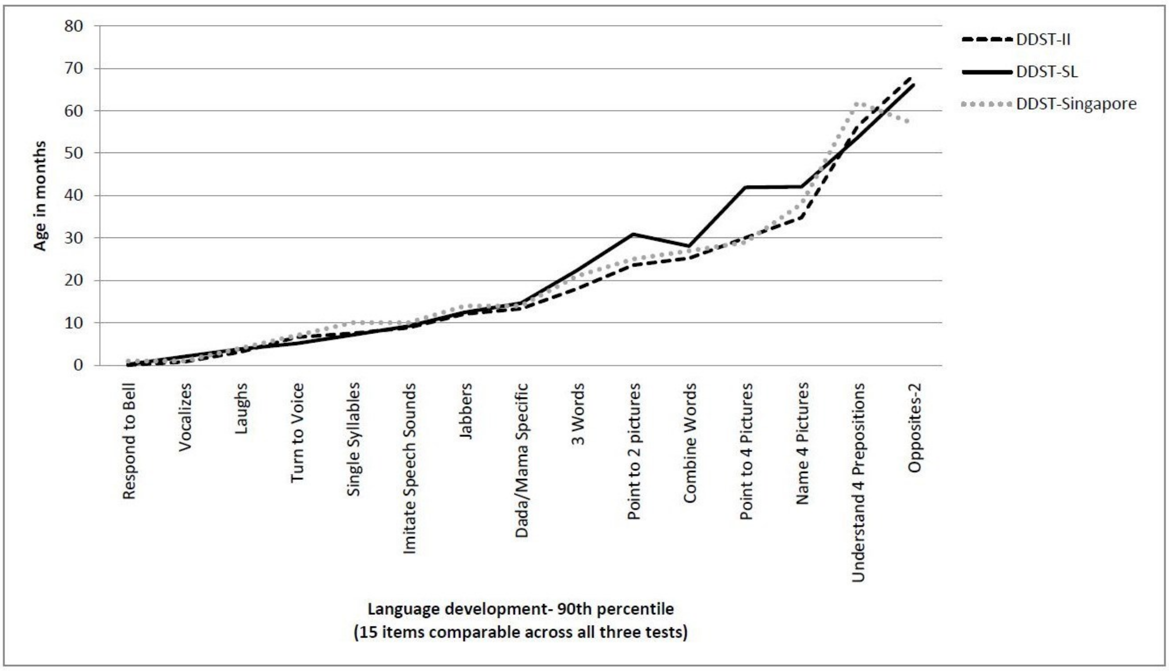


Figure 7. Comparison of the Denver Developmental Screening Test for Sri Lankan Children (DDST-SL), the Denver Developmental Screening Test-II (DDST-II) and DDST-Singapore language milestones (90th percentile age considered).



Comparison of DDST-SL with CHDR

In the CHDR, developmental milestones are not indicated as percentile passing ages as in DDST-II and DDST-SL. Developmental milestones have been compiled into 3-month blocks and are given as guidelines for child development until 5 years of age. Therefore, to enable comparison, the DDST-SL norms were categorized into blocks of 3 months similar to the CHDR considering the 90th percentiles ages of attaining the milestones. Although all 45 items in the CHDR were comparable with the items in DDST-SL, only 26 (48%) milestones were in the same age ranges.

Discussion

Public health nursing sisters were preferred as the data collectors as they are front-line health workers in the health system in Sri Lanka. The PHNS had a well-established rapport with the families and children and the data collection was carried out as an element of the routine weighing and immunization programmes. It was also assumed that test and stranger anxiety in children would be minimized due to their familiarity with the situation and the PHNS. Consequently, the PHNS did not report any refusals. There is a possibility that the refusals were not reported, or it might have been due to the deference shown within the Sri Lankan culture towards medical professionals.

The results of the study indicate that original developmental screening test norms may not be applicable to all child populations in the world and that they may not even be applicable to all children living within a particular geographical region. The newly established norms differ from those in the CHDR as well. This reiterates that performances on psychometric tests are influenced by context and that norms of developmental screening tests are not readily transferable across different child populations (Rydz *et al*. 2005).

This finding is supported by previous standardizations and adaptations of DDST and DDST-II, where results have yielded varying ages of acquiring developmental milestones (Bryant *et al*. 1974; Ueda 1978; Solomons 1982; Shapira & Harel 1983;Williams & Williams 1987; Lim *et al*. 1994; Kerfeld *et al*. 1997; Al-Naquib *et al*. 1999; Chikvinidze *et al*. 2003; Gladstone *et al*. 2008).

It is difficult to infer the exact reasons behind the variation seen between the developments of children in the three countries without conducting a study, across the three countries, with large enough samples, which would allow analyses of the influence of different ecological variables on child development. However, based on previous cross-cultural research, differences seen between the Sri Lankan norms and the other two developmental tools may be attributable to three reasons.

Firstly, DDST-II was administered in English, and DDST-Singapore was administered in Chinese, Malay or Tamil. The test administrations in Sri Lanka were carried out in Sinhalese and Tamil, the principal languages of Sri Lanka. As a test is translated and adapted for use, the issue of cross-cultural validity arises, as even identical test items constructed from accurate translations may not necessarily reflect the same functions, with comparable levels of difficulty (Chan *et al*. 2003; Carter *et al*. 2005).

Secondly, norms of both DDST-II and DDST-Singapore are based on data collected in 1988–1989. In addition to adequately representing the target population, the norms of a test must be current as normative data can become out of date due to cohort effects.

Finally, the ecology of the present cohort of Sri Lankan children differs to that of the children in Denver, CO, USA and Singaporean children. A detailed discussion of the differences between the ecologies of children in the three countries is not plausible within this paper. However, the early acquisition of more personal-social milestones by Sri Lankan children may be related to growing up within an extended family system. It may be hypothesized that support from other members of the family, which is readily available, may provide a more stimulating environment beyond that provided by a nuclear family system. The patterns of parental expectations for the development of their children in these different countries may also be different. While there is no previous literature available on the expectations of Sri Lankan parents for their children's development, it is well documented that parental expectations differ across cultures around the world (Hopkins & Westra 1990).

Moreover, the cultural differences seen in conversational styles used by parents (Hoff&Tian 2004)may have resulted in differential rates of language development. Many theorists over the years have discussed the importance of considering culture in child development (Super & Harkness 1986, 2002; Harkness & Super 1994; Pachter & Harwood 1996; Greenfield *et al*. 2003).

Additionally, in terms of country-specific influences, which may have contributed to the differential patterns of development, Sri Lanka boasts a free health and education system and primary school enrolment rate is 98% whereas the adult literacy rate is 90.7% (male 92.2%; female 89.2%; Department of Census and Statistics 2004).Moreover, the socio-economical conditions in Sri Lanka differ from that of the USA and Singapore as these are high-income countries and Sri Lanka is considered a middle income country (The World Bank 2011).

In standardization and adaptation of a test, it is useful to consider the effect of subgroups that can lead to differential patterns of child development *within* a country as well. Previous research studies indicate that the age of attaining development milestones may differ, for example, by maternal education and socio-economic status (Lim *et al*. 1994; Klebanov *et al*. 1998; Dollaghan *et al*. 1999; Wijedasa 2005). Identifying differential patterns of development in subgroups according to demographic variables would be beneficial, as it would allow the subgroups at risk to be documented. Thus, the next step would be to understand more about differences in development in the subpopulations of children in Sri Lanka.

Early childhood is a period for opportunities and risks, the influences of which may extend over a lifetime (Shonkoff 2010). Developmental screening can lead to the early identification of developmental delays in children. The results of this study emphasize that original test norms and even norms that have been adapted and standardized regionally may not be applicable to a particular child population in consideration. Therefore, it is imperative that child development is considered in context in test selection, administration and interpretation.

Key messages

• The results of this study indicate that performances on psychometric tests are influenced by the developmental context of children and that original norms of developmental screening tests are not readily transferable to different child populations across the world.

• Due to differences between subpopulations, developmental screening test norms may not even be applicable to all children living within a specific geographical region.

• When using developmental screening tests on a population of children other than the children that the original norms are based on, it is important to standardize andestablish local norms to avoid erroneous test results.

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